MATLAB/Simulink interface

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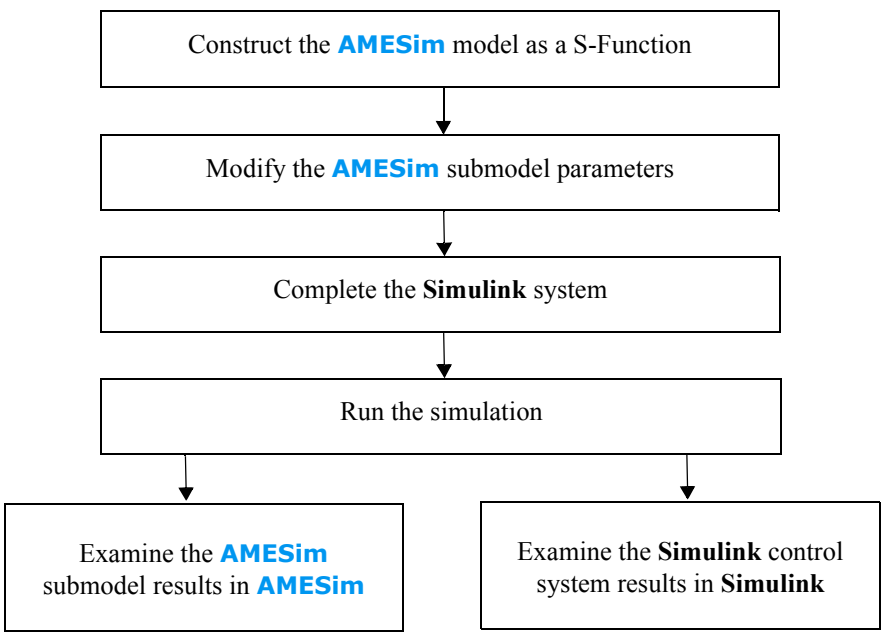
Using the AMESim MATLAB/Simulink Interface

1. Introduction

The **AMESim** **MATLAB/Simulink** interface enables you to construct a model of a subsystem in **AMESim** and to convert it to a **Simulink** S-Function. The S-Function can then be imported into **Simulink** and used within a **Simulink** system just like any other S-Function.

The interface is designed so that you can continue to use many of the **AMESim** facilities while the model is running in **Simulink**. In particular you can change the parameters of the **AMESim** model within **AMESim** in the normal way, examine the results within **AMESim** by creating plots just as if they were produced in a regular **AMESim** run.

Normally you will have **AMESim** and **Simulink** running simultaneously so that you can use the full facilities of both packages. The process is illustrated below:


Construct the AMESim model as a S-Function
Modify the AMESim submodel parameters
Complete the Simulink system
Run the simulation
Examine the AMESim submodel results in AMESim
Examine the Simulink control system results in Simulink

When the process is done, the **AMESim** model parameters may be changed within **AMESim**, as well as the **Simulink** parameters within **Simulink.** A series of runs can be performed. Typically, a controller can be designed for the system.

Organization of this manual

This manual describes both the standard interface (using the **Simulink** integrator) and the co-simulation interface (where integrators from both **Simulink** and **AMESim** are used). The main part of the manual deals with the standard interface and “Co-simulation interface”, page 17 looks at the differences between the standard and the co-simulation

interface.

The structure of this manual is the following:

- Section 2 describes how you must set your working environment so that you can use the interface.
- Section 3 describes with a simple example how the **AMESim** submodel is created and converted to an S-Function.
- Section 4 describes how the **AMESim** model is imported into and run within **Simulink**.
- Section 5 describes the differences between the co-simulation interface and the standard interface.
- Section 6 shows how to use more than one interface block in an **AMESim** model.
- Section 7 gives a summary of the most important things to remember, as well as as the answers to the most frequently asked questions (FAQ).
- Sometimes a section of text is only applicable to a UNIX or Linux environment. For such text the following presentation is used:

Using Unix:

Description for Unix/Linux environments.

- Sometimes a section of text is only applicable to a Windows environment. For such text the following presentation is used:

Using Windows:

Description for Windows environments.

Note that a collection of utilities also exists for **MATLAB** so as to import/export data to and from **AMESim**. These are documented in chapter 7 of the main **AMESim** manual. It is assumed that the reader of this manual is already familiar with **AMESim**, **MATLAB** and **Simulink**.

2. Preliminaries

2.1. C compiler requirements

If you work on a UNIX or Linux platform, you will need an ANSI C Compiler that is supported by **Simulink** for creating S-Functions.

If you work on a PC with Windows NT, Windows 2000 or Windows XP, **you must use Microsoft Visual C++** since it is the only compiler that can generate S-Functions for **Simulink**. The **GNU gcc compiler** supplied with **AMESim cannot be used**.

2.2. Supported versions of Simulink

AMESim	MATLAB	
	6.1 (r12.1) Simulink 4.1	6.5 (r13) Simulink 5.0
4.1	Yes	Yes
4.2	Yes	Yes

2.3. Setting up the environment

In order to use the **AMESim** **MATLAB/Simulink** interface it is necessary to set an environment variable that points out the **MATLAB** installation directory. If this is not set, **AMESim** will not be able to find the files necessary to create S-Functions.

To find out if this environment variable is set, type the following line in a terminal window:

Using Unix:

```
echo $MATLAB_ROOT
```

This should result in something like:

```
/opt/matlabr13
```

being printed on screen. If nothing is printed, or the message "MATLAB_ROOT: Undefined variable" is displayed, you must set this variable. To do this you need to know where **MATLAB** is installed. If your working environment is set up properly to run **MATLAB**, type either

`which matlab`	(if you are using Cshell) or
`whence matlab`	(if you are using Korn shell (ksh) or Bourne shell (sh)) or
`type matlab`	(for some versions of Bourne shells).

This will tell you the location of your version of **MATLAB** e.g.

```
/opt/matlabr13/bin/matlab
```

Remove the last two parts from this pathname to get the value to set for *MATLAB_ROOT,* in this case */opt/matlabr13*. If you are using the Unix C shell, you can then set the environment variable as follows:

```
setenv MATLAB_ROOT /opt/matlabr13
```

This statement can also be added to your *.cshrc* file so that the environment variable is set every time you login.

For Bourne or Korn shells the corresponding would be:

```
MATLAB_ROOT=/opt/matlabr13 ; export MATLAB_ROOT
```

Add these statements to your *.profile* file so that the environment variable is set every time you login.

Using Windows:

```
echo %MATLAB%
```

This should result in something like:

```
C:\MATLAB6p5
```

being printed on screen. If the environment variable is not set, `%MATLAB%` is printed and you need to set the *MATLAB* environment variable to point to the **MATLAB** installation directory. This can be done from the Windows Control Panel.

Another important point is that your path must contain the directory:

```
%windir%\System32
```

where %windir% is the Windows installation directory (a typical value for %windir% is C:\WINNT). You can check the content of your path by typing the command below and you can change it from the Windows Control Panel:

```
echo %Path%
```

2.4. Configuration files

This section is intended to advanced users only. It can be skipped at a first reading.

The configuration files for the **AMESim**/**Simulink** interface supplied with a standard **AMESim** installation assumes that all functions are written in C and that no extra libraries with user written functions are needed. If you write your submodels in Fortran or you use non-standard libraries in your model, some changes to the standard distribution files are needed. These changes can as all **AMESim** configurations be performed in two ways: globally for all users, or locally for the current directory (for a particular project).

The files that can be customized are *simulink.conf* and *simulink.make*. They normally exist in the *$AME/lib* or (*%AME%/lib*) directory. For global customization, they should be edited there. Your system administrator should normally handle this. For local configuration, copy these files to your project directory and make the necessary changes to these files. **AMESim** looks in the current directory before looking in the standard area (*$AME/lib* or *%AME%/lib*), any changes made to the local files will therefore override the global configuration. The file *simulink.conf* contains instructions on which files are to be used to create the S-Function for **Simulink**. This means that if you decide to make any local configurations this file *must* be edited, otherwise the global configuration will be used. The standard *simulink.conf* is shown in the following frame.

```
############################################################
#                                                          #
#  This file specifies the AMESim export facility to       #
#  Simulink. The entries are as follows:                   #
#                                                          #
#  1. the template to use for an explicit system.          #
#  2. the template to use for an implicit system.          #
#  3. the makefile to use.                                 #
#  4. the button title.                                    #
#  5. the script file to launch the companion software.    #
#                                                          #
############################################################

$AME/lib/imulink.etemp
NULL
$AME/lib/simulink.make
Simulink\nInterface
$AME/lib/simulink.launch
```

The lines beginning with # are comments. The line that all local configurations needs to change is the 3rd non-comment line (currently reading *"$AME/lib/simulink.make"*). This is the name of a file with instructions on how to create the **Simulink** S-Function. If you want **AMESim** to use your local configuration, change this line to *"./simulink.make"* for instance.

In the standard distribution, this file (*$AME/lib/simulink.make*) contains two lines, as in:

Using Unix:

```
${AME}/lib/amemex -c -g -I${AME}/lib

${AME}/lib/amemex
```

Using Windows:

```
$(CC) -c -g -DWIN32 -I${MATLAB}/extern/include -I${MATLAB}/
simulink/include

${AME}/lib/amemex
```

The first line is the command for compiling the **AMESim** generated C file. This system is dependent and may therefore be different on your installation.

The second line specifies the command used for creating the **Simulink** *mex* S-Function. This is a small shell script (*amemex*) that runs the **MATLAB** utility *mex*. All arguments are passed on to *mex*. By modifying *amemex* more advanced customizations can be made than

are possible using lines 1 and 3 in *simulink.make*.

Using Unix:

If your model includes Fortran code *simulink.make* probably needs to be altered by adding a 3rd line specifying the additional libraries needed. An example on such a line is:

```
-L/opt/SUNWspro/SC3.0.1/lib -lF77 -lsunmath
```

This is highly system dependent and you probably need to ask your system administrator for the libraries used on your computer. If many users are using Fortran it is probably a good idea to let your system administrator change the *simulink.make* in the standard area (*$AME/lib/simulink.make*).

Another reason to add a 3rd line is if your submodels use user written utilities or other non-standard files or libraries; this would typically be a change that you would do locally. For instance, if you would like to include a library called *libmyfuncs.a* which is stored in */home/my_name/library* add the following line:

```
-L/home/my_name/library -lmyfuncs
```

If there already is a 3rd line in *simulink.make*, for instance for using Fortran, add your files at the beginning of the line as in:

```
-L/home/my_name/library -lmyfuncs -L/opt/SUNWspro/SC3.0.1/lib
-lF77 -lsunmath
```

Using Windows:

A reason to add a 3rd line is if your submodels use user written utilities or other non-standard files or libraries; this would typically be a change that you would do locally. For instance, if you would like to include a library called *myfuncs.lib* which is stored in *C:\home\my_name\library* add the following line:

```
-link -libpath:C:\home\my_name\library myfuncs.lib
```

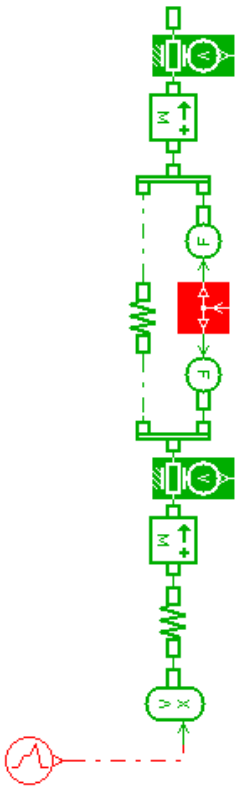
or

```
C:\home\my_name\library\myfuncs.lib
```

Each **AMESim** model ‘remembers’ which *simulink.conf* was specified when it was created. This means that for any new simulation, the corresponding *simulink.make* will be used. Hence, it is necessary to rebuild the special icon created for the **AMESim/Simulink** interface, if you wish your model to use a different *simulink.make.*

3. Constructing the model in AMESim

Figure 1: The model in AMESim.



The process of constructing the **AMESim** model is described with the help of a simple example. You will understand the process better if you create and run the system yourself. The exercise can be completed within about an hour.

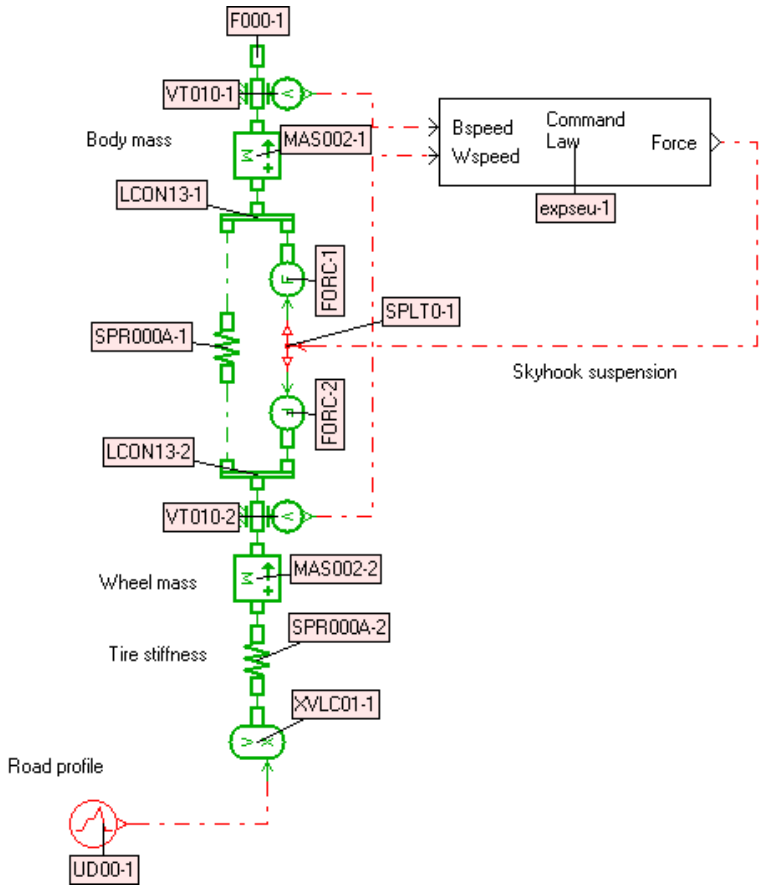
Create the system shown in Figure 1: The model in AMESim. calling it *skyhook*. It consists of two masses connected with a spring which represent a quarter car suspension.

Note:

- Two transducers determine the positions of the wheel and the car body.
- Connected to the wheel is a spring to which the road profile is applied.

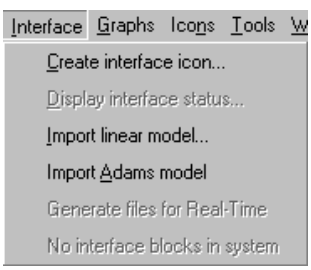
- The system is incomplete with three ports unconnected.

Figure 2: The AMESim model with the interface block.



The force representing the damping in the suspension will be provided by **Simulink** and the output from the velocity transducers will be sent to **Simulink**. To complete the system it is necessary to add a special interface icon. Figure 2 shows this block added to the system.

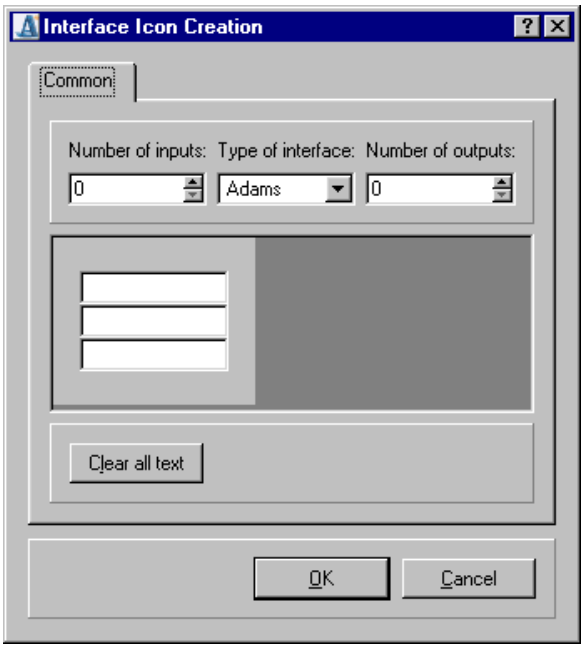
Figure 3: First step in creating the interface icon.



To create the interface blocks, click on the *Interface* pulldown menu shown in Figure 3. This menu is designed to be used with the **Simulink** interface and other interfaces but in our case it will be **Simulink**. Select the item labeled *Create interface icon*. This is used to define the variables which are provided and received by the companion software. From **AMESim** these variables are seen as inputs and outputs respectively. The dialog box

shown in Figure 4 is produced.

Figure 4: Interface Icon Creation dialog box.

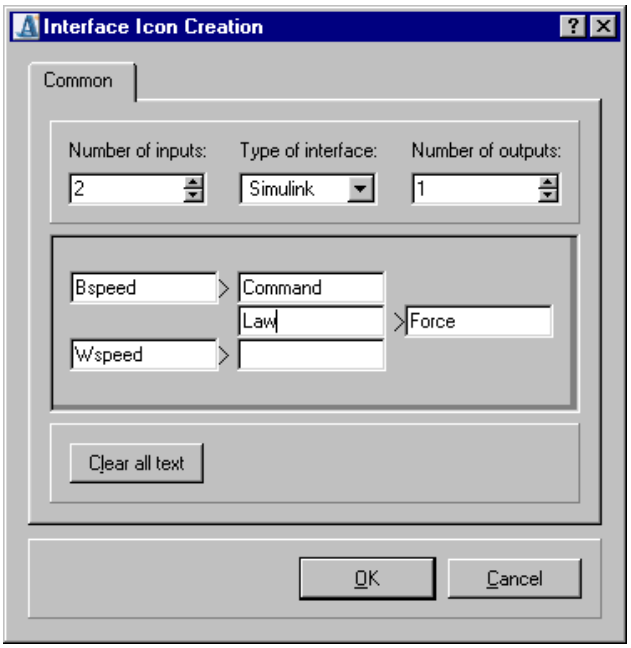


Notice that in this figure there is a field with the label *Adams* in it. This must be changed by clicking on the arrow in the right of the field and by selecting *Simulink* as in Figure 5. There is currently no input and output variable. By selecting the arrow buttons in the top corners, the number of input or output variables can be adjusted. You can have any number including 0 but a reasonable upper limit is 10. If you want more than this, it is better to use more than one interface block. In our example, we require two input variables and one output variables, so ensure that the fields have the values 2 and 3 respectively.

The next stage is to get **AMESim** to create a specific icon for the interface. The number of ports is now specified but it is also necessary to add a label to each port. Hence, we will add text to give a name to the variables. In addition, we will give a general name for the whole interface block. Figure 5 shows text added in this way. Select each field and type an

appropriate text string.

Figure 5: Specifying the interface block.

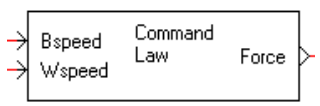


Note the three buttons labeled *Clear all text*, *OK* and *Cancel*.

- Click on *Cancel* to abandon the process.
- Click on *Clear all text* to remove any text you have entered.
- Click on *OK* to obtain the icon produced by **AMESim**.

An icon similar to that shown in Figure 6 will appear. Note the port position is denoted by >.

Figure 6: The completed interface block.



The pointer will take on the appearance of the icon and can be treated like a normal **AMESim** component icon. Thus it can be mirrored, rotated, deleted or added to system sketch. All **AMESim** interface blocks have signal type ports.

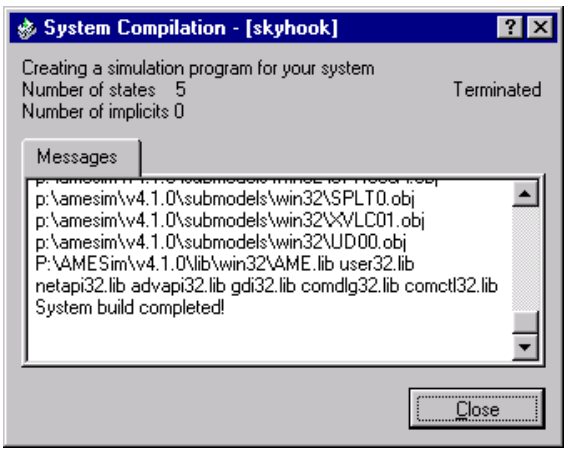
Connect the block inputs and output to the other components of the model as shown in Figure 2.

It is worth mentioning 2 important points:

- You can have more than one interface block but if you do, they must all be of the same type (all Simulink standard interface blocks in the current example);
- the **AMESim** model must be explicit i.e. there cannot be any implicit variables, unless the co-simulation interface is used.

Change now to *Submodel* mode. The interface block will automatically be associated with a special submodel and you are not allowed to change these. For the other submodels select *Premier submodel* so as to get the simplest submodels.

Figure 7: Compilation to create the S-Function.



Next, change to *Parameter* mode. Normally **AMESim** would create an executable program that you would start in *Run* mode. However, because the system contains **Simulink** interface blocks, an S-Function is created. The normal *System Compilation* window should appear (as in Figure 7) and the *Parameter* mode should be entered. If any error occurs, it is likely that the *MATLAB* environment variable is not properly set. In this case save the system, exit from **AMESim** and carry out the instruction for setting this variable as described in section 2.

Enter new parameters for the components to values shown in the table below, leave all other parameters at their default values:

Submodel	Name on sketch if any	Title	Value
MAS002	Body mass	mass [kg]	400
		inclination (+90 port 1 lowest, -90 port 1 highest) [degree]	-90
SPR000A		spring rate [N/m]	15000
		spring force with both displacements zero [N]	400*9.81
MAS002	Wheel mass	mass [kg]	40
		inclination (+90 port 1 lowest, -90 port 1 highest) [degree]	-90
SPR000A	Tire stiffness	spring rate [N/m]	200000
		spring force with both displacements zero [N]	440*9.81

UD00		duration of stage 1 [s]	0.1
		output at start of stage 2 [null]	0.1
		output at end of stage 2 [null]	0.1
		duration of stage 2 [s]	3

When you change from *Parameter* mode to *Run* mode, special data files containing the parameters are written. When you run the S-Function within Simulink, these files will be read. Hence, when you change any parameters, ensure you enter the *Run* mode. If not, your changes will not be seen by Simulink.

At this point, you are ready to run the **AMESim** model within **Simulink**. In order to start **Simulink**, you have two possibilities:

- In the normal way: from a suitable shell window (Unix) or by double-clicking on its associated icon (Windows). **If you do this you must ensure that the Matlab *Current Directory* is set to the directory where the AMESim model is stored.** A browser button can help you for this:

- Alternatively, you can use the **Tools ▶ Start Matlab** menu from **AMESim**. In this case the **Matlab** *Current Directory* is automatically set to the directory where the **AMESim** model is stored.

4. Importing the model into Simulink

The **AMESim** model at this stage exists as an S-Function. It must be imported into **Simulink**. Remember that when you quit **AMESim**, the files defining your system are compressed into a single file. This means that **Simulink** would not have access to the S-Function. For this reason, it is normal to have **AMESim** and **Simulink** running simultaneously when using the interface. This way, you can change the parameters in the **AMESim** model and restart the simulation very rapidly. You can also examine the results in **AMESim**.

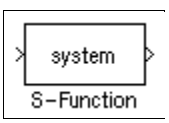
Another mode of working is to quit **AMESim** but then to type in a terminal (Unix) or DOS (Windows) window:

```
AMELoad skyhook
```

to expand the single file into its constituent parts. **Simulink** will then have access to all the files it needs.

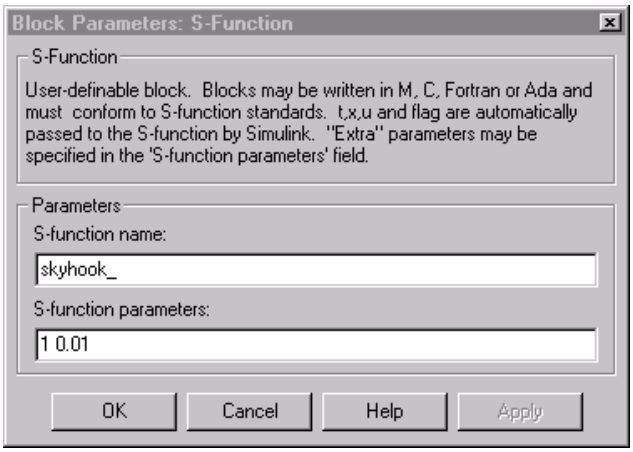
For the rest of this exercise it will be assumed you employ the first mode of working.

Figure 8: The S-Function in Simulink.



From within **Simulink** select the S-Function block (Figure 8) and add it to the display area, then set the parameters as shown in Figure 9. The name of the S-Function is *skyhook_* i.e. the name of the system with an '_' added. This name must be entered in the first box. In the input box below this, two parameters must be entered. These are used to specify the characteristics of the **AMESim** result files.

Figure 9: The S-Function parameters.


Block Parameters: S-Function
S-Function
User-definable block. Blocks may be written in M, C, Fortran or Ada and must conform to S-function standards. t,x,u and flag are automatically passed to the S-function by Simulink. "Extra" parameters may be specified in the 'S-function parameters' field.
Parameters
S-function name:
skyhook_
S-function parameters:
1 0.01
OK
Cancel
Help
Apply

With a normal **AMESim** run, a print interval is specified whereby the size of the results file can be controlled. **Simulink** runs in a somewhat different way and consequently the **AMESim** result files can become unacceptably large. To prevent this from occurring a special **AMESim** print interval is specified in the S-Function. The data added to the **AMESim** results file will be spaced with a time interval **not less than this value**.

- The first parameter indicates whether an **AMESim** results file is to be created. A value of 1 indicates it is to be created and any other number indicates it is not to be created.
- The second parameter indicates the special print interval. If a zero or negative value is entered, **Simulink** will add to the **AMESim** results file whenever it adds to its own results.

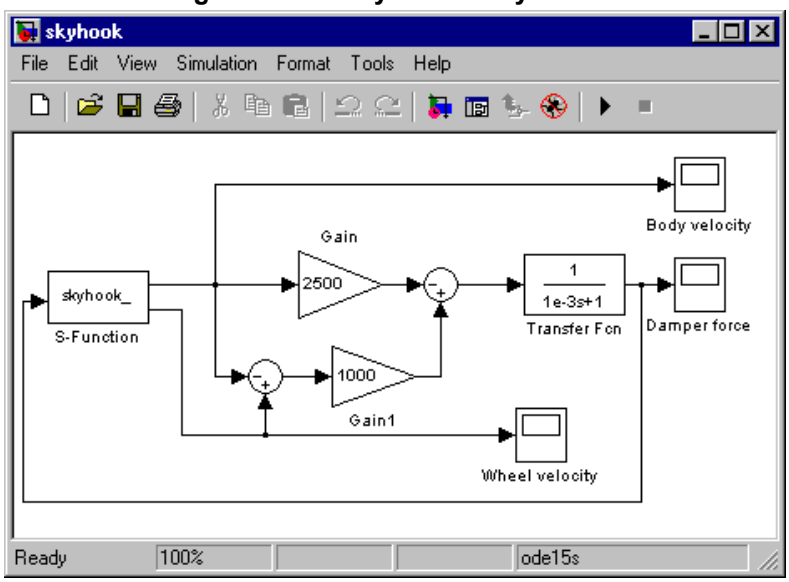
Add the values shown in Figure 9 so that there will be an **AMESim** results file but with a print interval restriction of 0.01 s.

Complete the system as shown in Figure 10. Note that there are gain blocks, as well as summing junctions. The outputs from the S-Function are passed through the *Demux* block to split the output array from **AMESim** to form the two outputs *Bspeed* and *Wspeed.*

Users of previous versions of the AMESim-Simulink interface should notice that the output dealing with discontinuities has been removed. The discontinuities are now dealt

with internally in the S-Function.

Figure 10: The system ready to run.



Values of *Gain* and *Gain 1* come from the car suspension example in Chapter 4 of the **AMESim** manual.

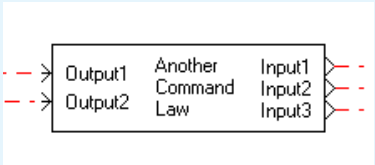
Why has the transfer function been inserted? This is a consequence of the fact that the **AMESim** S-Function is defined as having direct feed through. This means that the outputs from the block may be directly dependent on the input. For most realistic **AMESim** systems this is not true, there are normally state variable(s) between input and output. The way the S-Function is created makes it necessary to specify that all systems have a direct feed through anyway.

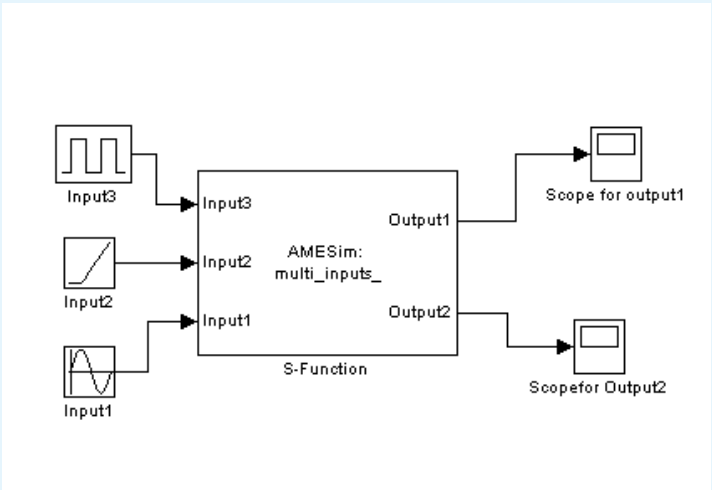
The transfer function (a first order lag) that is inserted is required to break the algebraic loop that **Simulink** sees due to this direct feed through. For the current system it can be regarded as the dynamics of the actuator that applies the damping force.

Important note:

If your **AMESim** model has more than one input coming from **Simulink**, the input signals to **AMESim** have their order reversed when compared to what is sent from **Simulink**. This is due to the fact that **AMESim** numbers the ports in counter-clockwise order while the *Mux* block in **Simulink** numbers them starting at the top. The output side of the interface block is not affected by this, since in this case the variables are numbered from the top in both softwares. This can be seen by comparing the model in **AMESim** and **Simulink** as shown in the figures below:

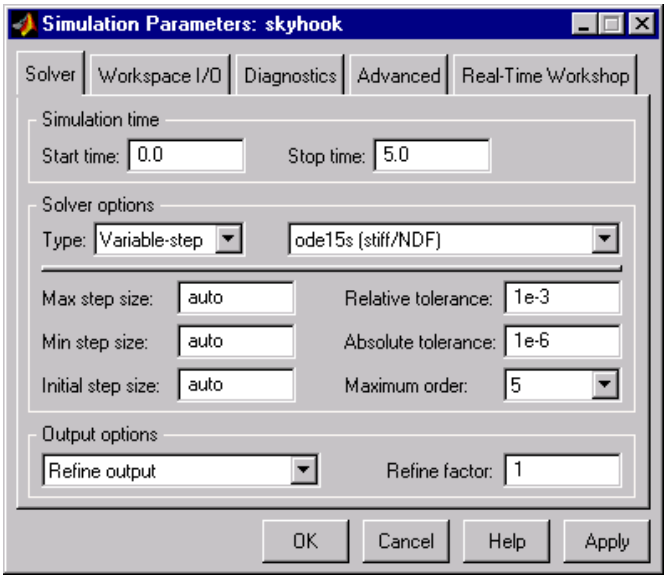
Figure 11: Order of inputs and outputs.





Next, set the simulation parameters to the values shown in Figure 12. Remember that **AMESim** systems can be numerically stiff, this is particularly true for hydraulic and *HCD* systems. This means that some of the time constants are very small and there can be very fast dynamics. For this reason, the only integration methods likely to succeed are the ones that are specially designed for this.

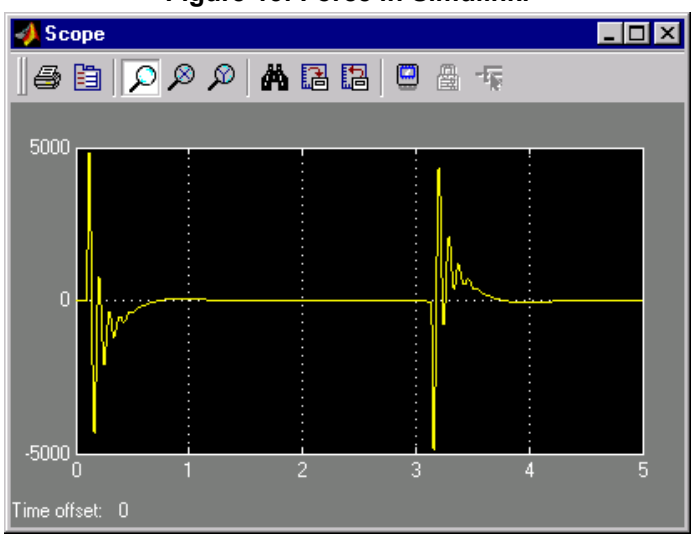
Figure 12: Setting the simulation parameters.



In **Simulink** it seems that both solvers for stiff systems are possible to use for **AMESim** models. In this particular case, use the *ode15s* (stiff/NDF) method (in older versions, *Gear* and *Adams/Gear* were the ones most suitable). Set the stop time to 5 seconds, this will be quite enough to produce some interesting results.

Initiate the **Simulink** run and watch the output from the *Scope* block. This will give the input force supplied to the car suspension as shown in Figure 13: Force in Simulink..

Figure 13: Force in Simulink.



Notice that after starting the first run from **Simulink**, the appearance of the *S-Function* icon is slightly altered: the name of the ports are added. If you want to see these names more

clearly you must adjust the size of this icon:

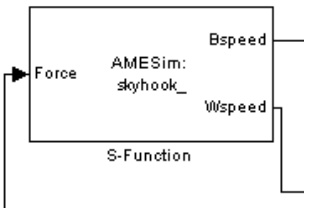


Figure 14 shows the same quantity plotted within **AMESim**. If you chose to generate an **AMESim** result file, it is possible from within **AMESim** to access the full range of variables of the **AMESim** model. These can be plotted as from a normal **AMESim** simulation, Figure 15 shows the body and wheel displacements.

Figure 14: Force in AMESim.

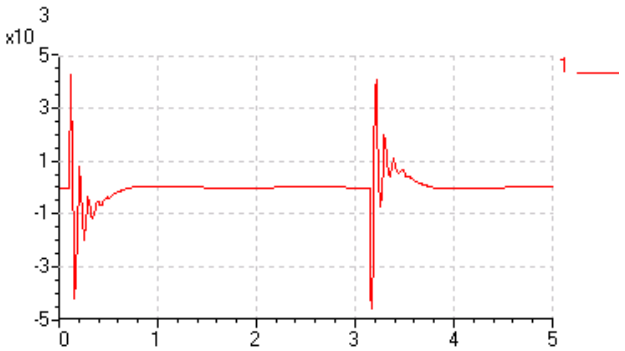
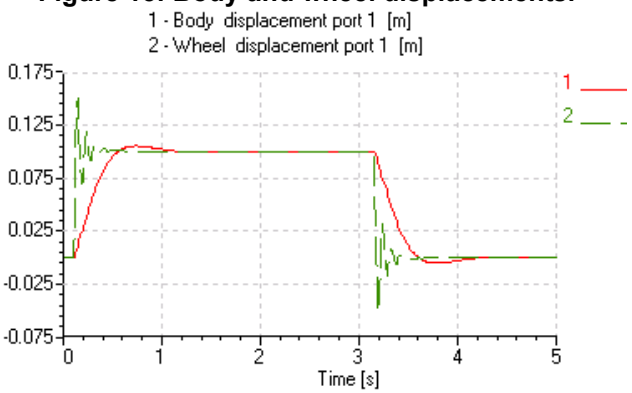


Figure 15: Body and wheel displacements.



5. Co-simulation interface

Two possibilities are offered to create an interface with **Simulink**: the standard interface and the co-simulation interface. Here we will explain what the differences are between the two, and describe how to use the co-simulation interface.

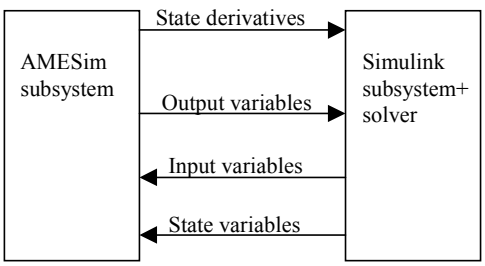
5.1. Introduction

The main difference between the two interfaces is that co-simulation interface uses two (or more) solvers, while the standard interface uses only one. This means that **AMESim** and **Simulink** use their own solver for the co-simulation interface whereas they both use the **Simulink** solver for the standard interface. Another difference is that with the standard interface the **AMESim** part is seen as a time continuous block in **Simulink** and in the co-simulation it is a time discrete block. Since the co-simulation block is seen as a discrete block it makes this interface very suitable for discrete controllers implemented in **Simulink** controlling an **AMESim** model.

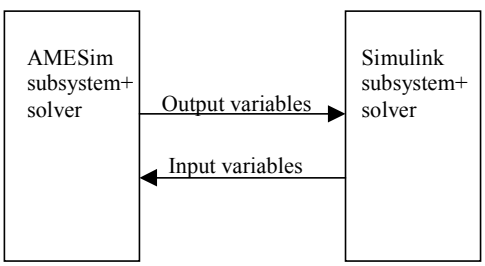
The figure below shows in more detail how the interfaces work. In the standard interface the **AMESim** part of the system gets state variables and input variables from **Simulink** and calculates state derivatives and output variables. The process of exchanging this information is controlled entirely by the **Simulink** solver. In this case one could say that we import the equations into **Simulink**.

In the co-simulation case, the only exchanged variables are the input and output variables. The rate of exchange is in this case decided by a parameter that the user decides. As the name indicates the model is not entirely in the hands of one software (**Simulink**) but it is a co-operation between two (or more) software. It is important to realize that by exchanging only input and output variables at a certain sample rate there is a loss of information.

Figure 16: The two AMESim-Simulink interfaces, exchange of information.



Normal interface



Co-simulation interface

This can be compared with the difference between a continuous and a sampled controller. Normally the smaller sample rate used the closer to the continuous result we get. Another possible problem is that the we loose information about possible cross couplings between the system since we do not communicate information about states and state derivatives.

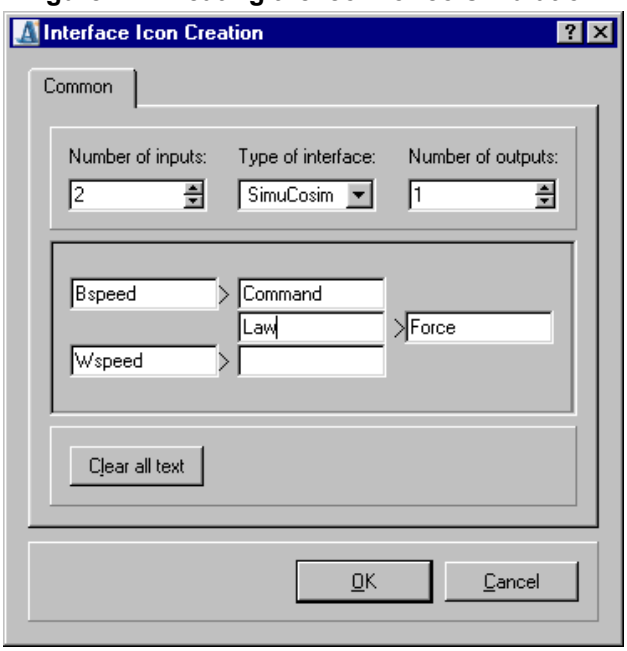
All these factors mean that co-simulation can be difficult to set up if the two separate systems are continuous. You should in that case try to find an interface between the systems where the coupling is as weak as possible.

The obvious situation where co-simulation may be used is of course when the interface between the system is sampled, for instance when using a sampled controller.

5.2. Usage of the co-simulation interface

We will reuse the **AMESim** system created earlier (Figure 1: The model in AMESim.). Save the system as *skyhookcosim*. Now we add the interface block. The process is similar to the process creating the standard **Simulink** interface, except that we select *SimulCosim* in the field labeled *Type of interface* instead of *Simulink.* See Figure 17:

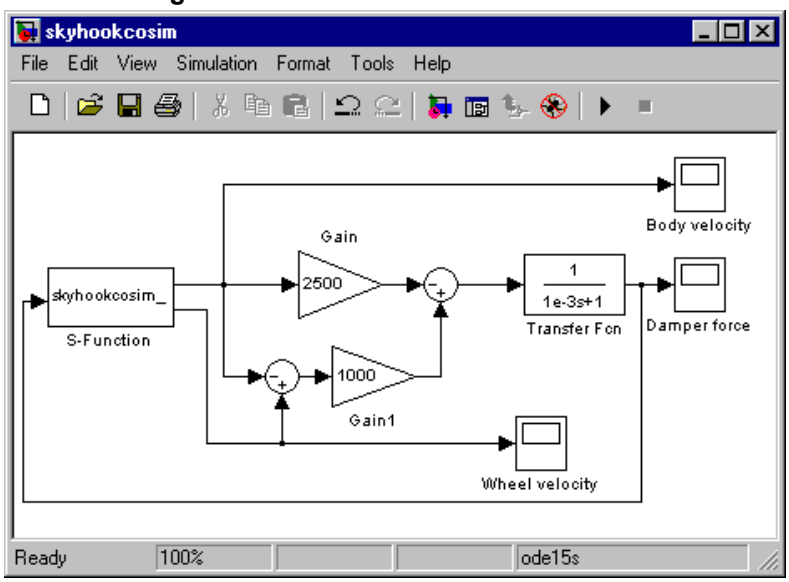
Figure 17: Creating the icon for co-simulation.



Go into *Parameter* mode and then *Run* mode. Next we create the **Simulink** system as shown in Figure 18: Simulink model - Co-simulation. We use the same basic system as before with the difference that the name of the S-Function is now *skyhookcosim_*.

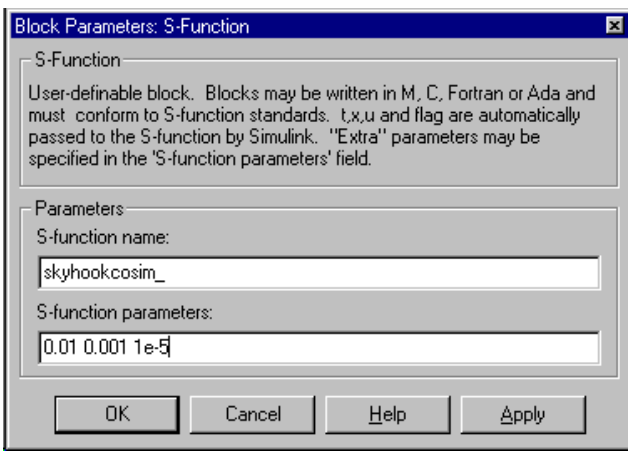
In **Simulink** the only difference is the number and type of parameters of the S-Function.

Figure 18: Simulink model - Co-simulation



Looking at the parameters for the S-Function as shown in Figure 19 we can see that more than two parameters are used. However it is possible to give it only two parameters; in that case the other parameters will get default values.

Figure 19: The S-Function Parameters.


Block Parameters: S-Function
S-Function
User-definable block. Blocks may be written in M, C, Fortran or Ada and must conform to S-function standards. t,x,u and flag are automatically passed to the S-function by Simulink. "Extra" parameters may be specified in the 'S-function parameters' field.
Parameters
S-function name:
skyhookcosim_
S-function parameters:
0.01 0.001 1e-5
OK
Cancel
Help
Apply

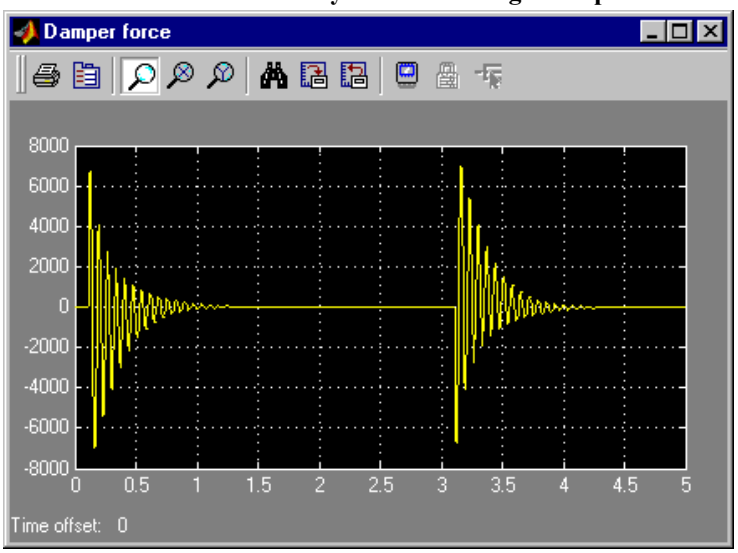
The list of parameters of the S-Function is shown in the following table. Note that if we want to set a value for the 4th parameter, it is necessary to give a value to all parameters before this one.

Parameter	Description	Default value
Sample time	Time between exchange of values between AMESim and Simulink	Required, no default value
AMESim communication interval	As in AMESim	Required, no default value
Tolerance	the same as in the AMESim run parameters popup	1.0e-5
Max time step	the same as in the AMESim run parameters popup	1.0e20 s
Time range	Helps DASSL to decide initialize the time step	100 s (do not change)
Show run statistics	0 or 1, 1 for displaying run statistics	1
Extra discontinuity points	0 or 1, 1 for extra discontinuity printouts	0
Output details	0 or 1, 1 for output of time on screen (not useful on PC)	0

The chosen sample time is on purpose chosen fairly large in this example to make the effects of the sampling more obvious. The chosen sample time is for this case the maximal sampling time possible to use. The damping force calculated by the **Simulink** model is shown in Figure 20: Force as calculated by Simulink using a sample time of 0.01s, compare this with the force in Figure 13: Force in Simulink.. The stability of the system has gone

down due to the sampled controller.

Figure 20: Force as calculated by Simulink using a sample time of 0.01s



Looking more closely on the input to the **AMESim** system (Figure 21: Detailed view of force input to AMESim model using sample time of 0.01s.) one clearly sees the time discrete nature of the force. The sampled controller results in body and wheel displacements that are more oscillatory (Figure 22: Body and wheel displacement with a sample time of 0.01s.) than with the continuous controller (Figure 15: Body and wheel displacements.). By selecting a smaller sample time we can get a result that is more similar to the one we had with the standard interface (continuous controller). In Figure 23: Body and wheel displacement with a sample time of 0.001s. and Figure 24: Actual input to the AMESim model using a sample interval of 0.001s. the sample time is set to 0.001s and the

AMESim communication interval is set to 0.0002s.

Figure 21: Detailed view of force input to AMESim model using sample time of 0.01s.

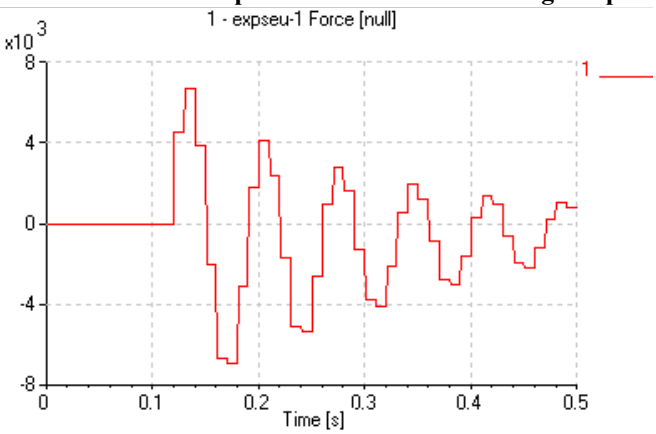


Figure 22: Body and wheel displacement with a sample time of 0.01s.

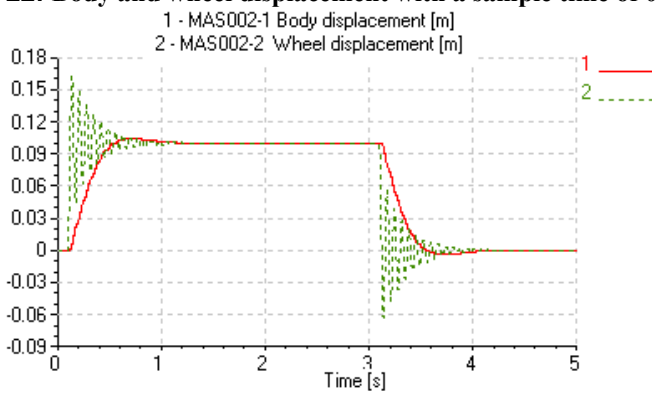


Figure 23: Body and wheel displacement with a sample time of 0.001s.

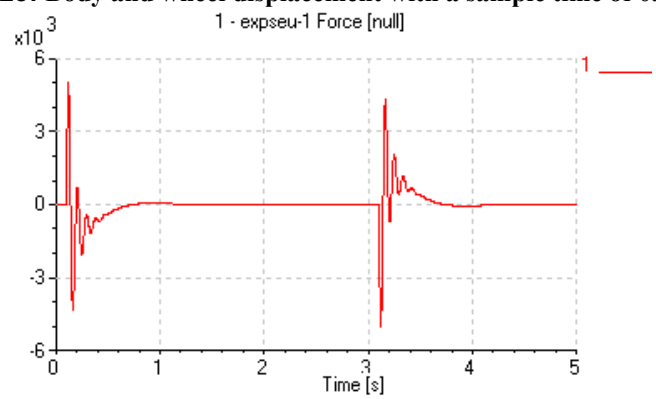
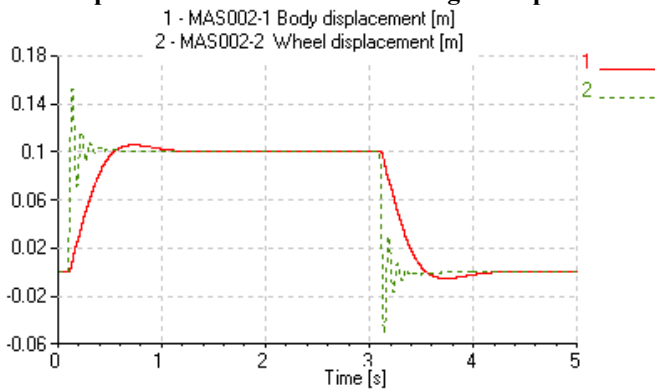
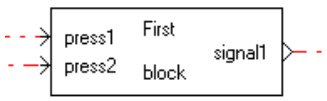
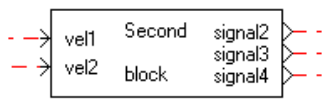


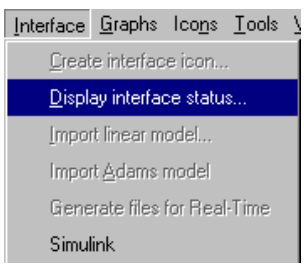
Figure 24: Actual input to the AMESim model using a sample interval of 0.001s.



6. Using more than one interface block



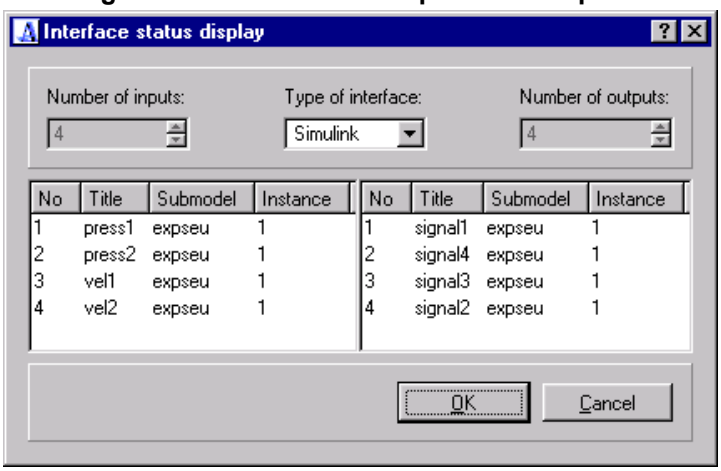




Make sure you give each port a unique name.

When the S-Function is created, **AMESim** will concatenate all the inputs and concatenate all the outputs. To see how this is done, select **Interface ▶ Display interface status**. A dialog box (Figure 25) shows how the ports are arranged.

Figure 25: Concatenated inputs and outputs.



7. Concluding remarks and FAQs

7.1. Concluding remarks

This manual has presented a simple example to introduce the use of the **Simulink** interface. Before you start developing your own models, we now summarize the most important points:

- If you work on a PC with Windows NT, Windows 2000 or Windows XP, **you must use Microsoft Visual C++** since it is the only compiler that can generate S-Functions for **Simulink**. The **GNU gcc compiler** supplied with **AMESim cannot be used**.
- The input of the interface block in **AMESim** has its ports in reverse order compared with **Simulink.**
- Remember to change from *Parameters* to *Run* mode in **AMESim** before running the simulation in **Simulink** or to use **File ▶ Write aux. files.**
- For systems using the standard **Simulink** interface the following points are important:
  - The **AMESim** model must be explicit i.e. there cannot be any implicit variables. The reason for this is that the **Simulink** integrators can handle only ordinary differential equations.
  - **Users of previous versions of the AMESim-Simulink interface should notice that the output dealing with discontinuities (Hit Crossing) has been removed**.
- For systems using the *co-simulation* interface it is important to think of the following:
  - Remember that the **AMESim** block is seen as a discrete block from **Simulink**.
  - The parameters to the S-Functions are as shown in the table in section *5.2. Usage of the co-simulation interface*, and they are not the same as the parameters for the standard interface.

7.2. Common problems and their solutions

Compilation failure with a *Line too long* error message

Versions

All **Matlab** versions under Windows.

Situation

- When compiling an **AMESim** system containing interface blocks, the compilation fails and the following error message is displayed in the *AMESim* compilation window: '*...Line too long...*'.
- Furthermore, the *DLL* file representing the S-Function is not generated. And when trying to run the simulation in **Simulink**, an error message indicates that the S-Function does not exist.

Solution

- Close the current **AMESim** session and login with Administrator privileges.
- First check that the *AME* environment variable points to the **AMESim** installation directory.
- Go to the *%MATLAB%\bin\win32\mexopts* directory (where *%MATLAB%* is the **Matlab** installation directory).

  Depending on the MS Visual C++ version you use, copy the following file and paste it into the *%AME%\lib* directory (where *%AME%* is the **AMESim** installation directory):

  for Visual C++ 5, copy *msvc50opts.bat*,

  for Visual C++ 6, copy *msvc60opts.bat* and

  for Visual.NET, copy *msvc70opts.bat*.
- Go to the *%AME%\lib* directory.
- Drag the *msvc..opts.bat* file and drop it onto the *install_big_simulink_interface.exe* file:

  one file is generated: *mexopts.bat* and

  one file is modified: *simulink.make*.
- Logout and login with your user account.
- Launch **AMESim** and re-compile the system.

Compilation window is blocked during the first use of the interface

Versions

All **Matlab** versions under Windows.

Situation

- The **AMESim**/**Simulink** interface is used for the first time.
- When compiling the **AMESim** system with **Simulink** blocks, the compilation window in **AMESim** seems to be blocked and the following pieces of information are displayed:

Select a compiler:

[1] Digital Visual Fortran version 6.0 in C:\Program Files\Microsoft Visual Studio

[2] Lcc C version 2.4 in C:\MATLAB6P5\sys\lcc

[3] Microsoft Visual C/C++ version 6.0 in C:\Program Files\Microsoft Visual Studio

[0] None

Solution

AMESim is waiting for the user to select a compiler:

- Right click at the bottom of the compilation window.
- A menu labeled *Interactive compilation* appears.
- Select this menu: a blank field appears at the bottom of the compilation window.
- Type the index corresponding to the Microsoft Visual C++ compiler in this field (3 in this example) and hit the **Enter** key.
- The compilation starts.

Not possible to run sequential simulations

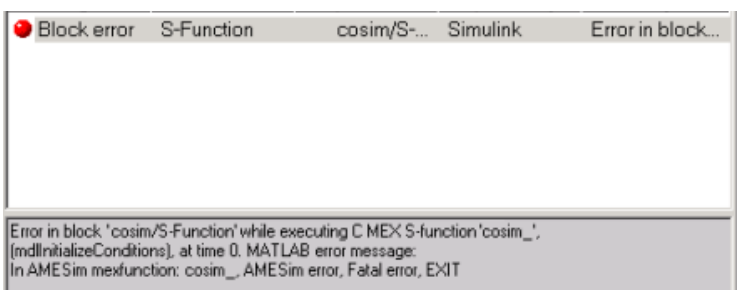
This used to be a common problem but the solution has been partially automated and fortunately now is much rarer.

Versions

Matlab r11, r12 and r13 under Unix, Linux and Windows.

Situation

- A **Simulink** model containing the S-Function corresponding to an **AMESim** model (.DLL, .mexsol, ...) is opened.
- The first simulation in **Simulink** works fine.
- When running a new simulation, the following error message (mdlInitializeConditions) is systematically displayed:


Block error
S-Function
cosim/S-...
Simulink
Error in block...
Error in block 'cosim/S-Function' while executing C MEX S-function 'cosim_',
(mdlInitializeConditions), at time 0. MATLAB error message:
In AMESim mexfunction: cosim_, AMESim error, Fatal error, EXIT

Solutions

Under most circumstances it is necessary to force **Simulink** to reload the **AMESim** model for each new simulation. To avoid any problem, it is recommended that this is done **always**.

One way to achieve this is to clear the **AMESim** mex function from (**Matlab**) memory before starting a new simulation. This can be done in three ways, manually or

automatically:

- The manual way is to type "`clear mex`" or "`clear xxxx_`" where `xxxx` is the **AMESim** system name. This needs to be done before each new simulation starts (or after each simulation).
- In **Simulink** version 2 and higher it is possible to specify a command to be executed after each simulation. Taking the **Simulink** system in Figure 10: The system ready to run. as an example we can type:

  ```
  set_param('skyhook/S-Function','StopFcn','clear skyhook_')
  ```

  at the **Matlab** command prompt. This makes **Simulink** unload the **AMESim** mex function after each simulation, and thus forcing it to be reloaded when a new simulation is run.

If the Java interface (**Matlab** 6 or higher) is used, a menu item **File ▶ Model properties** exists in the **Simulink** menu bar that does the same thing as the set_param command. In the *Simulation stop function* zone add the expression "`clear xxxx_`" where `xxxx` is the **AMESim** system name. Click on the *Apply* button. Save the **Simulink** model so that modifications are definitely taken into account.

Reporting Bugs and using the Hotline Service

AME is a large piece of software containing many hundreds of thousands of lines of code. With software of this size it is inevitable that it contains some bugs. Naturally we hope you do not encounter any of these but if you use **AME** extensively at some stage, sooner or later, you may find a problem.

Bugs may occur in the pre- and post-processing facilities of **AMESim**, **AMERun**, **AMESet**, **AMECustom** or in one of the interfaces with other software. Usually it is quite clear when you have encountered a bug of this type.

Bugs can also occur when running a simulation of a model. Unfortunately it is not possible to say that, for any model, it is always possible to run a simulation. The integrators used in **AME** are robust but no integrator can claim to be perfectly reliable. From the view point of an integrator, models vary enormously in their difficulty. Usually when there is a problem it is because the equations being solved are badly conditioned. This means that the solution is ill-defined. It is possible to write down sets of equations that have no solution. In such circumstances it is not surprising that the integrator is unsuccessful. Other sets of equations have very clearly defined solutions. Between these extremes there is a whole spectrum of problems. Some of these will be the marginal problems for the integrator.

If computers were able to do exact arithmetic with real numbers, these marginal problems would not create any difficulties. Unfortunately computers do real arithmetic to a limited accuracy and hence there will be times when the integrator will be forced to give up. Simulation is a skill which has to be learnt slowly. An experienced person will be aware that certain situations can create difficulties. Thus very small hydraulic volumes and very small masses subject to large forces can cause problems. The *State count* facility can be useful in identifying the cause of a slow simulation. An eigenvalue analysis can also be useful.

The author remembers spending many hours trying to understand why a simulation failed. Eventually he discovered that he had mistyped a parameter. A hydraulic motor size had been entered making the unit about as big as an ocean liner! When this parameter was corrected, the simulation ran fine.

It follows that you must spend some time investigating why a simulation runs slowly or fails completely. However, it is possible that you have discovered a bug in an **AMESim** submodel or utility. If this is the case, we would like to know about it. By reporting problems you can help us make the product better.

On the next page is a form. When you wish to report a bug please photocopy this form and fill the copy. You telephone us, having the filled form in front of you means you have the information we need. Similarly include the information in an email.

To report the bug you have three options:

- reproduce the same information as an email
- telephone the details
- fax the form

Use the email address, telephone number or fax number of your local distributor.

HOTLINE REPORT

Creation date: *Created by:*

Company: *Contact:*

Keywords (at least one):

Problem type: ☐ **Bug** ☐ **Improvement** ☐ **Other**

Summary:

Description:

Involved operating system(s):

☐ **All**	☐ **Unix (all)**	☐ **PC (all)**
	☐ **HP**	☐ **Windows 2000**
	☐ **IBM**	☐ **Windows NT**
	☐ **SGI**	☐ **Windows XP**
	☐ **SUN**	☐ **Linux**
	☐ **Other:**	☐ **Other:**

Involved software version(s):

☐ **All**	☐ **AMESim (all)**	☐ **AMERun (all)**	☐ **AMESet (all)**	☐ **AMECustom (all)**
	☐ **AMESim 4.0**	☐ **AMERun 4.0**	☐ **AMESet 4.0**	☐ **AMECustom 4.0**
	☐ **AMESim 4.0.1**	☐ **AMERun 4.0.1**	☐ **AMESet 4.0.1**	☐ **AMECustom 4.0.1**
	☐ **AMESim 4.0.2**	☐ **AMERun 4.0.2**	☐ **AMESet 4.0.2**	☐ **AMECustom 4.0.2**
	☐ **AMESim 4.0.3**	☐ **AMERun 4.0.3**	☐ **AMESet 4.0.3**	☐ **AMECustom 4.0.3**
	☐ **AMESim 4.1**	☐ **AMERun 4.1**	☐ **AMESet 4.1**	☐ **AMECustom 4.1**

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